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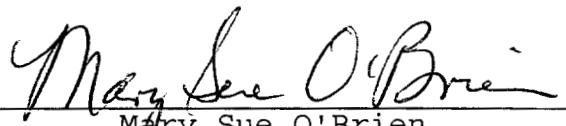
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TITLE SIMULATIONS OF SOLAR WIND PLASMA FLOW AROUND A SIMPLE SOLAR SAIL		OTHER AUTHORS Joseph Wang	<input type="checkbox"/> Premeeting publication <input checked="" type="checkbox"/> Publication on meeting day <input type="checkbox"/> Postmeeting publication <input type="checkbox"/> Poster session <input type="checkbox"/> Handouts
KEY WORDS FOR INDEXING (Separate items with commas) Spacecraft Charging, Solar Sails, Solar Wind			
THIS WORK: <input type="checkbox"/> Covers new technology not previously reported <input type="checkbox"/> Covers work previously reported in New Technology Report (NTR) No. _____ <input type="checkbox"/> Provides more information for earlier NTR No(s). _____ <input checked="" type="checkbox"/> Contains no new technology		LEAD JPL AUTHOR'S SIGNATURE DATE 6/18/2003 SECTION OR PROJECT LEVEL APPROVAL - I attest to the technical accuracy of this document /web site. DATE 6-18-03	
ORIGINATING ORGANIZATION (Section, Project, or Element Number) 513		PERFORMING ORGANIZATION (If different)	
ACCOUNT CODE OR TASK ORDER (For tracking purposes only) 101611-5RR03		DOCUMENT NUMBER(S), RELEASE DATE(S)	DATE RECEIVED 6/19/03 DATE DUE 6/30/2003
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Web Site: Preclearance URL (JPL internal) _____ Postclearance URL (external) _____			
<input type="checkbox"/> Brochure/Newsletter <input type="checkbox"/> JPL Publication <input type="checkbox"/> Section 274 Editor (If applicable) _____ <input type="checkbox"/> Journal Name _____ <input checked="" type="checkbox"/> Meeting Title <u>8th Spacecraft Charging Technology Conference</u> Meeting Date <u>10/20/03-10/24/03</u> Location <u>Huntsville, AL</u> Sponsoring Society <u>NASA MSFC</u> <input type="checkbox"/> Book/Book Chapter <input type="checkbox"/> Assigned JPL Task <input type="checkbox"/> Private Venture Publisher _____			
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SIMULATIONS OF SOLAR WIND PLASMA FLOW AROUND A SIMPLE SOLAR SAIL

INTERACTIONS OF SPACECRAFT AND SYSTEMS WITH THE NATURAL AND INDUCED PLASMA ENVIRONMENT

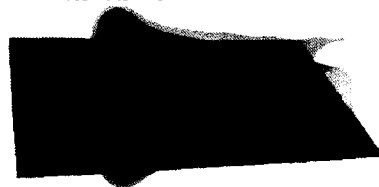
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In recent years, a number of solar sail missions of various designs and sizes have been proposed (e.g., GEOSTORM). Indeed various groups, both private and governmental, are in the process of building either flight or prototype solar sails. Of potential importance to these missions is the interaction of the ambient solar wind plasma environment with the sail. The solar wind plasma in interplanetary space can vary over a wide range: from $<1 \text{ cm}^{-3}$ to $\sim 80 \text{ cm}^{-3}$ in density, from $\sim 200 \text{ km/s}$ to over 2000 km/s in velocity, and from 0.5 eV to $\sim 100 \text{ eV}$ in temperature. Assuming a "typical" 1 AU solar wind environment of 400 km/s velocity, 3.5 cm^{-3} density, ion temperature of $\sim 10 \text{ eV}$, electron temperature of 40 eV , and an ambient magnetic field strength of 10^{-4} G , we have carried out a first order estimate of the plasma interaction with square solar sails on the order of the sizes being considered for a GEOSTORM mission ($50 \text{ m} \times 50 \text{ m}$ and $75 \text{ m} \times 75 \text{ m}$ corresponding to ~ 2 and ~ 3 times the Debye length in the plasma). First, the crude current balance for the sail surface immersed in plasma environment and in sunlight was used to estimate the surface potential of the model sails (the surfaces in this initial study are assumed to be made of thin, uniformly conducting aluminum). This gives surface potentials of $\sim 10 \text{ V}$ positive relative to the solar wind plasma. A 3-D, Electrostatic Particle-in-Cell (PIC) code was then used to simulate the solar wind flowing around the solar sail. It is assumed in the code that the solar wind protons can be treated as particles while the electrons follow a Boltzmann distribution. The electric field and particle trajectories are solved self-consistently to give the proton flow field, the electrostatic field around the sail, and the plasma density in 3-D. Representative figures are given below. The sail is found to be surrounded by a plasma sheath within which the potential is positive compared to the ambient plasma and followed by a separate plasma wake which is negative relative to the plasma. This structure departs dramatically from a negatively charged plate such as might be found in the Earth's ionosphere on the night side where both the plate and its negative wake are contiguous. The talk will discuss the implications of these findings and discuss further areas of study in solar wind/solar sail plasma interactions.



Positively Solar Sail in Solar Wind



Negatively Charged Plate in Solar Wind